Report for 2003CT24B: Handheld Light Meters and Anion Exchange Membranes to Reduce the Threat of Water Pollution from Turfgrass Fertilizers

- Articles in Refereed Scientific Journals:
    - Mangiafico, S.S. and K. Guillard, Anion Exchange Membrane Soil Nitrate Predicts Turfgrass Color and Yield. Submitted to Crop Science.
- Conference Proceedings:
    - Mangiafico, S.S. and K. Guillard, 2004, Use of Anion Exchange Membranes to Estimate Turfgrass Growth and Quality, in Agronomy Abstracts: Proceedings of the National Meeting of the American Society of Agronomy, Madison, WI.
    - Mangiafico, S. S. and K. Guillard, 2004, Desorbed Nitrate from Anion Exchange Membranes as a Predictor of Nitrate Leaching and Turfgrass Color., in Agronomy Abstracts: Proceedings of the National Meeting of the American Society of Agronomy, Madison, WI.

Report Follows

Problem

Traditional agricultural crop production in southern New England has declined rapidly during the last 30 years. As urban and suburban development encroaches into rural landscapes, turf is replacing cropland as the principal managed land cover in the region. Although these areas are not regarded as agricultural cropland, they may receive comparable or greater amounts of fertilizers than are applied to cropland. Because a large land area devoted to fertilized turf (residential and commercial lawns, golf courses, athletic and recreational fields, sod farms) in Connecticut and other Eastern states is located adjacent to pond, lake, river, and coastal shorelines, N losses from turf may contribute significantly to the degradation of sensitive N-limited ecosystems when the total N load over a larger geographical area is considered. This is particularly critical for Connecticut coastal, bay, and estuarine ecosystems that have been documented as experiencing frequent hypoxia events attributed to non-point sources of nutrients. Despite concerns with nutrient losses from turf, there has been relatively little research and improvements in traditional fertilization practices of turfgrass in the past 30 years. There are no soil-based N tests currently used to guide N fertilization for turf, and only a few golf course superintendents use tissue N testing on a routine basis. The majority of turf managers and homeowners still rely on decades-old fertilization recommendations where N is applied on a schedule or at set rates based on history rather than being based on criteria of nutrient availability provided by an objective testing method like a soil test. This increases the likelihood of excess N applications that threaten water quality. Preliminary data from my laboratory suggest that handheld meters and anion exchange membranes (AEMs) have great potential in fine-tuning N management for turf. Establishment of a database utilizing tristimulus and reflectance meter readings and desorbed nitrate–N (NO_3–N) from AEMs will allow for the determination of optimum N fertilization to turf that will decrease the chances of excessive N fertilization that can cause pollution problems.

Research Objectives

- Determine the relationship between soil nitrate–N (desorbed from anion exchange membranes) and turf growth and quality responses.

- Determine the relationship between soil nitrate–N (desorbed from anion exchange membranes) and nitrate leaching from turf.

- Determine the relationship between soil nitrate–N (desorbed from anion exchange membranes) and nitrogen recovery by turfgrass.

- Determine the relationship between tristimulus and reflectance meter readings and nitrate leaching from turf.

Methodology

Field experiments were conducted at the University of Connecticut's Plant Science Research and Teaching Facility using established plots of mixed-species cool-season turfgrass managed as home lawns. Treatments consisted of nine N fertilization rates: 0, 5, 10, 20, 30, 40, 50, 75, and 100 kg N per hectare per month. Anion exchange membranes were inserted into each of the plots and replaced on two-week intervals to monitor soil nitrate dynamics *in situ*. A Minolta CR-200 tristimulus chroma meter and a Spectrum CM1000 chlorophyll meter were used to determine hue (greenness), lightness (brightness of color), chroma (saturation of color), and relative chlorophyll content of the turf. Measurements of the turf included shoot growth (clipping yield), color (hue, lightness, chroma), relative chlorophyll content (Spectrum CM1000 index), and total N concentration. These variables were correlated to nitrate–N desorbed from AEMs. Curvilinear models were used to suggest critical values for soil nitrate–N corresponding to optimum turf responses.

A soil monolith lysimeter experiment was conducted in a greenhouse and consisted of 64 undisturbed soil columns that were collected from a sod farm in Wethersfield, CT. The columns were seeded to a Kentucky bluegrass blend and fertilized with 16 rates of N: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, and 100 kg N per hectare per month. Anion exchange membranes were inserted into each column and replaced on two-week intervals. A Minolta CR-200 tristimulus chroma meter and a Spectrum CM1000 chlorophyll meter were used to determine turf color quality, and clipping yield and total N concentration were measured every two weeks. The columns were irrigated weekly at 2.5 cm per week. The upper 1.5 cm of turf sod in the columns was removed after the natural growing season ended in November and irrigation was continued. This was done to prevent continued uptake of fertilizer N and allow for N to leach from the columns during a period of minimal turf growth, which would occur naturally during the winter and before regrowth in the spring. Percolate samples were collected weekly and analyzed for concentrations of NO_3–N. Nitrate leaching losses and meter readings were correlated to nitrate–N desorbed from AEMs. Curvilinear models were used to relate nitrate leaching to AEM soil NO_3–N and reflectance meter measurements.

Principle Findings and Significance

Results from the field study suggest that AEM desorbed NO_3–N can be used to predict a critical level needed for maximizing turf color and growth (Fig 1). Little change was noted in greenness of the turf (CIE hue), relative chlorophyll content (CM1000 index), and growth (clipping yield) above an AEM desorbed NO_3–N value of approximately 3 μg/cm^2/day. Any further increase in available soil N did not increase turf greenness, but presumably increased the chance of N losses with excess soil NO_3–N.

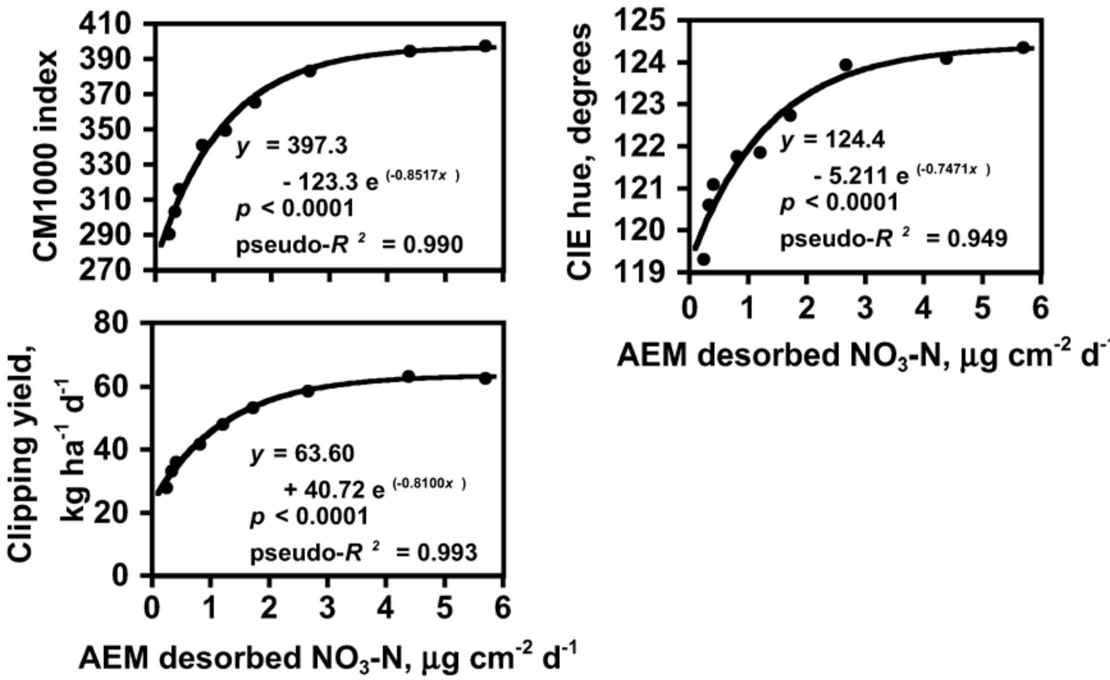

Fig 1. Relationship between soil nitrate–N desorbed from anion exchange membranes (AEMs) and CIE hue (greenness), CM1000 index (relative chlorophyll), and clipping yield (growth) collected from a Kentucky bluegrass–perennial ryegrass–creeping red fescue lawn. Each data point represents the mean of three replications averaged across two growing seasons.

Results from the soil column study indicate that desorbed soil nitrate–N from AEMs has potential to accurately predict percolate nitrate–N concentrations and mass losses from turf (Fig. 2). The data indicate that percolate nitrate–N concentrations and mass losses will increase at an exponential rate with increasing N availability in the soil. Little change was noted, however, in relative chlorophyll content (CM1000 index), and growth (clipping yield) above an AEM desorbed NO_3–N value of approximately 4 μg/cm^2/day (Fig. 3). This suggests that NO_3–N leaching losses will increase if turf is fertilized beyond the point of N sufficiency in the soil, even though turf quality will not improve beyond this point.

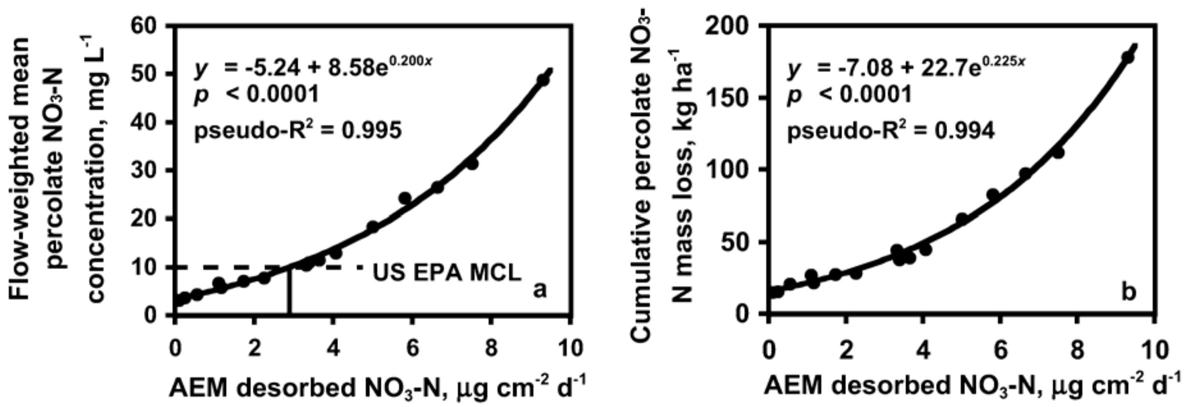

Fig 2. Relationship between soil nitrate–N desorbed from anion exchange membranes (AEMs) and flow-weighted nitrate–N concentrations and leaching losses of percolate collected from Kentucky bluegrass grown in soil columns. Each data point represents the mean of four replications averaged across two growing seasons.

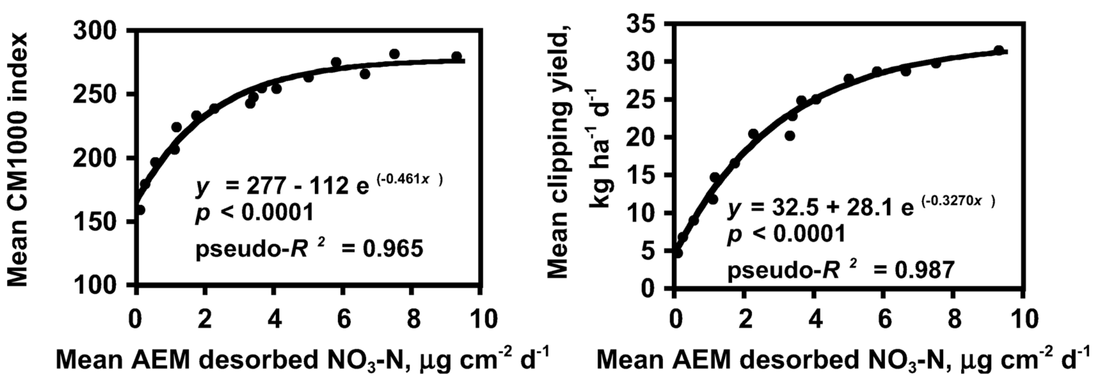

Fig 3. Relationship between soil nitrate–N desorbed from anion exchange membranes (AEMs) and CM1000 index (relative chlorophyll) and clipping yield (growth) collected from Kentucky bluegrass grown in soil columns. Each data point represents the mean of four replications averaged across two growing seasons.

The chlorophyll meter was useful as well in predicting N leaching losses in this study (Fig. 4). Nitrate–N leaching increased exponentially as turf greenness (CIE hue) and relative chlorophyll content (CM1000 index) increased. However, increases were moderate up to a CIE hue value of approximately 250 and a CM1000 index value of approximately 124. These data suggests that turf may be fertilized to some level of color quality with moderate NO_3–N leaching losses, beyond this incremental color changes will be achieved at the expense of exponentially higher NO_3–N leaching.

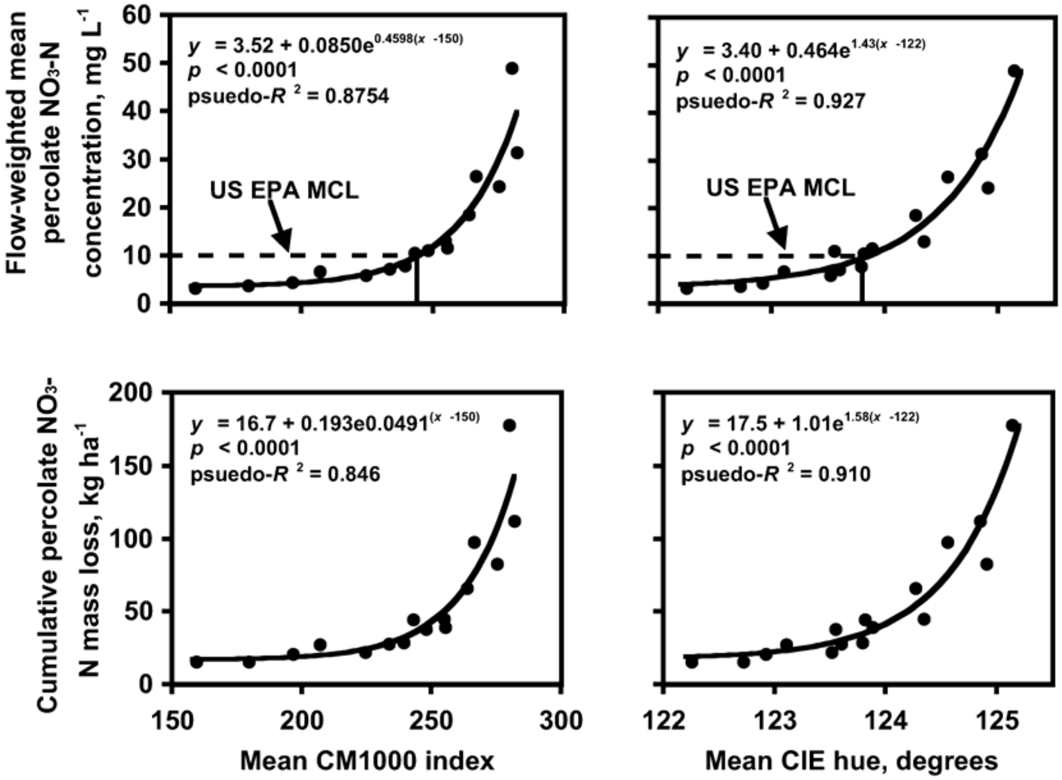

Fig 4. Relationship between CM1000 index (relative chlorophyll) and CIE hue (greenness) and flow-weighted nitrate–N concentrations and leaching losses of percolate collected from Kentucky bluegrass grown in soil columns. Each data point represents the mean of four replications averaged across two growing seasons.

These preliminary results suggest that N management of turf can become less subjective and more reliable with the use of handheld reflectance meters and AEMs. This is a significant improvement over the current methods (visual or scheduled application rates) used for turf and marks an important step forward in turf nutrient management. In the absence of a quantitative method to indicate excess N availability for certain turf growth and quality measures, the likelihood of over-application of N increases. As more of the landscape in the Northeast and elsewhere is converted from farmland to suburban and urban use, nutrient management of turf will come more important because of water quality concerns.